



Egyptian Society of Radiology and Nuclear Medicine  
**The Egyptian Journal of Radiology and Nuclear Medicine**

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## ORIGINAL ARTICLE

# Can DWI & ADC differentiate orbital lymphoma, non-specific orbital inflammation and orbital cellulitis?

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Received 7 February 2012; accepted 15 February 2012

Available online 14 March 2012

### KEYWORDS

DWI;  
ADC;  
NSOI;  
Orbital lymphoma;  
Cellulitis;  
Non-specific orbital  
inflammation

**Abstract** *The aim of this work:* To differentiate orbital lymphoma, non-specific orbital inflammation (NSOI) and orbital cellulitis using DWI & ADC, as there is marked clinical overlap in the diagnosis of these three orbital conditions.

*Material and methods:* Twenty-five cases chosen from attendants of the outpatient clinic of the Ophthalmology Department of Zagazig University Hospitals with different orbital pathologies presenting with orbital inflammatory signs and/or proptosis were all examined with conventional MRI sequences then functional DWI and ADC map and values were performed.

*Results:* Six cases (6/25) were diagnosed as orbital lymphomas (24%), 14 cases (14/25) NSOI (formerly known as orbital inflammatory syndrome) (56%) and 5 cases (5/25) as orbital cellulitis (20%), in DWI the greater the restriction was detected in lymphomas, followed by NSOI and lastly with orbital cellulitis and ADC values ranging from  $0.6$  to  $0.9 \times 10^{-3} \text{ mm}^2/\text{s}$  for lymphoma,  $1.1$  to  $1.3 \times 10^{-3} \text{ mm}^2/\text{s}$  in NSOI and  $1.5$  to  $1.7 \times 10^{-3} \text{ mm}^2/\text{s}$  in orbital cellulitis.

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**Conclusion:** DWI & ADC can differentiate orbital lymphoma from NSOI and orbital cellulitis and help rapid management.

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## 1. Introduction

Diffusion weighted image (DWI) and apparent diffusion coefficient (ADC) are promising magnetic resonance imaging techniques that may help to distinguish different orbital pathologies including benign and malignant lesions (1). Because orbital cellulitis is a life-threatening condition, therefore urgent imaging modalities are indicated to assess the anatomic extent of the disease (2).

DW imaging has been increasingly used to differentiate and to characterize different head and neck lesions (1), DW is predominantly applied for acute ischemic infarcts revealing high signal intensity on DW and low signal on apparent diffusion coefficient (ADC) (3–5).

Orbital cellulitis with abscess formation shows restricted diffusion pattern on DW due to viscosity and dense cellular packing of the purulent materials within the central cavitations (6,7). Within the central abscess cavity, the DWI shows high signal intensity associated with low signal intensity on ADC representing diffusion restriction, this is an important finding differentiating

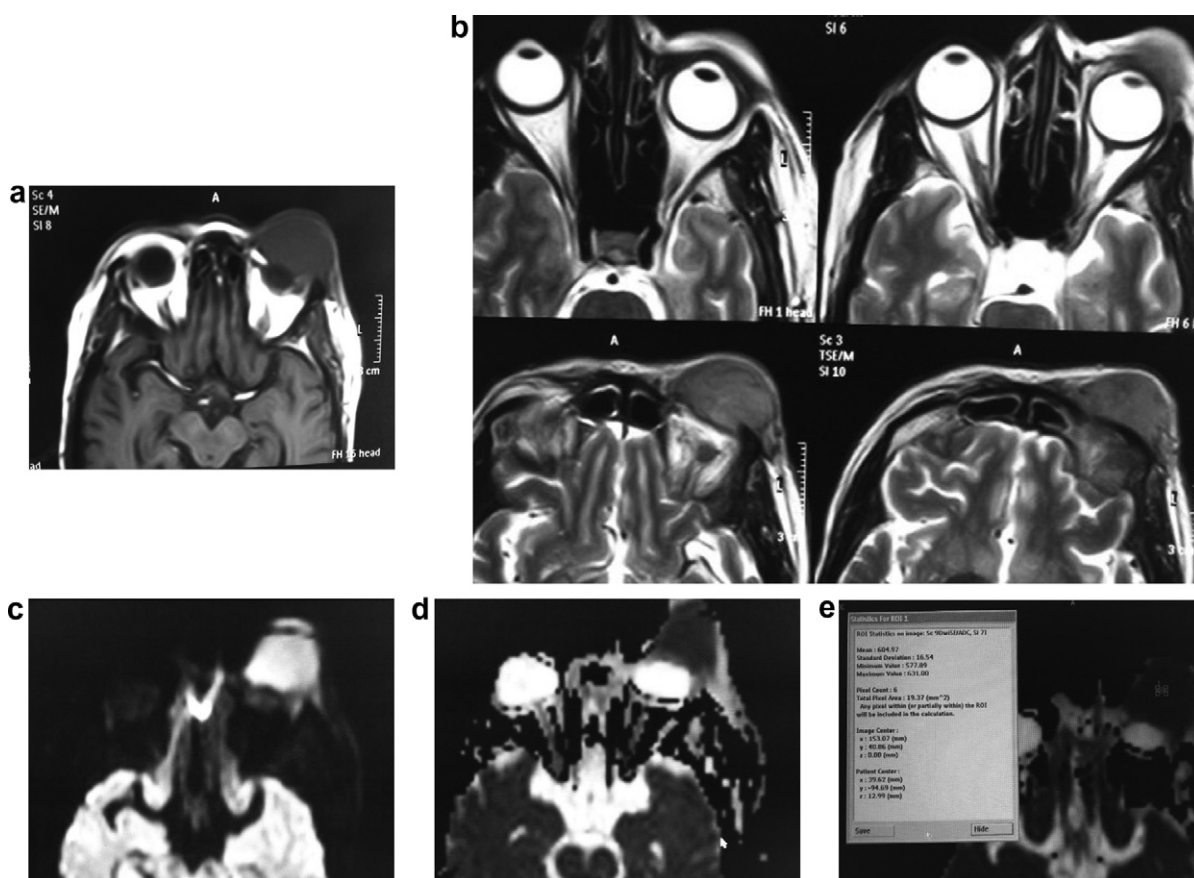
the abscess cavity from peripherally enhanced lesions like necrotic tumors in which there is free facilitated diffusion (7,8).

So when the orbital lesions displayed cystic patterns, it is essential to differentiate whether this cyst is an abscess cavity or cystic necrotic tumor and the conventional MR even with contrast cannot clearly depict the pathology, so the new MR imaging techniques like DWI that depend on molecular motion of water can be used with standard MR examination of the orbit (1,3).

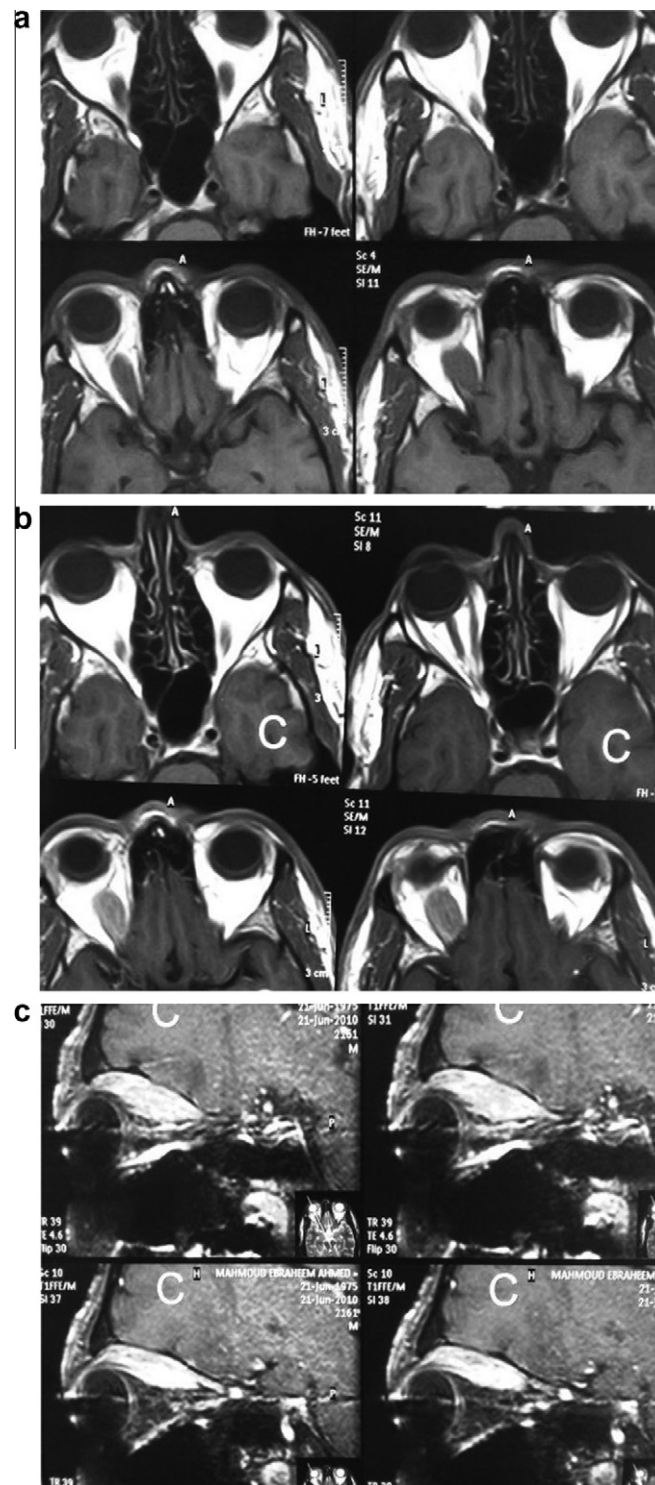
## 2. Material and methods

Twenty-five cases were chosen from attendants of the outpatient clinic of the Ophthalmology Department of Zagazig University Hospitals, with different orbital pathologies presenting with orbital inflammatory signs and/or proptosis.

All cases were subjected to thorough history-taking and careful ophthalmological examination including best-corrected visual acuity, degree and direction of proptosis, IOP measurement and fundus examination.



**Fig. 1** Left orbital lymphoma. (a and b) T1 and T2 WI show ill-defined soft tissue intensity mass at left preseptal space. (c) DWI shows bright signal (restricted diffusion). (d) Low signal at ADC. (e) ADC value =  $0.6 \times 10^{-3} \text{ mm}^2/\text{s}$ .



**Fig. 2** Right NSOI. (a) T1 WI shows diffuse enlargement of the right superior rectus muscle. (b and c) Mild-to moderate heterogeneous enhancement and obliterated retro-orbital fat. (d) DWI shows intermediate bright signal (less restriction). (e) Intermediate signal at ADC. (f) ADC value =  $1.28 \times 10^{-3} \text{ mm}^2/\text{s}$ .

All these patients (25) were subjected to the following MRI sequences at the MR unit of the Radiology Department of Zagazig University Hospitals:

- (1) Axial T1WI (TR 148-597/TE 2-15).
- (2) Axial T2WI (TR 4400-4800/TE 110).
- (3) Post-contrast T1WI with or without fat suppression sequence.
- (4) Diffusion weighted image (DWI) for all patients:  
The patient's position was the same examining position of the brain MRI in the supine position with head coil.

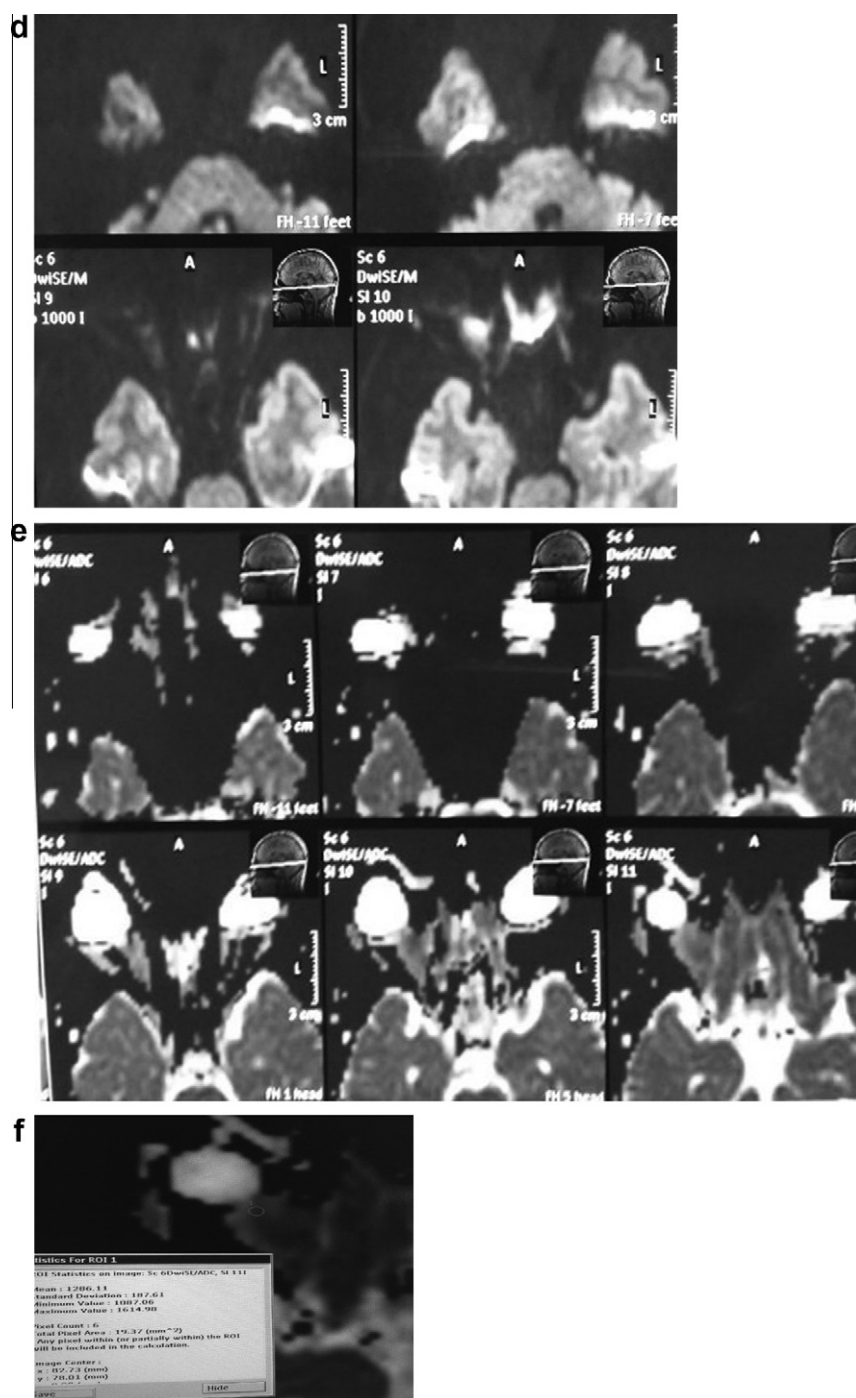


Fig. 2 (continued)

\* Two sets of images were used in clinical practice: the  $b = 0$  T2W images and the  $b = 1000$  average images. Scanning time was 1 min 15 s.

(5) ADC maps were automatically calculated by MRI machine software and included in the sequence.

\* Post-processing of DWI: region of interest (ROI) was selected in the area of the lesion.

### 3. Results

Twenty-five patients with different orbital pathologies were included in this study (16 males and 9 females), their age ranged from 7 to 65 years.

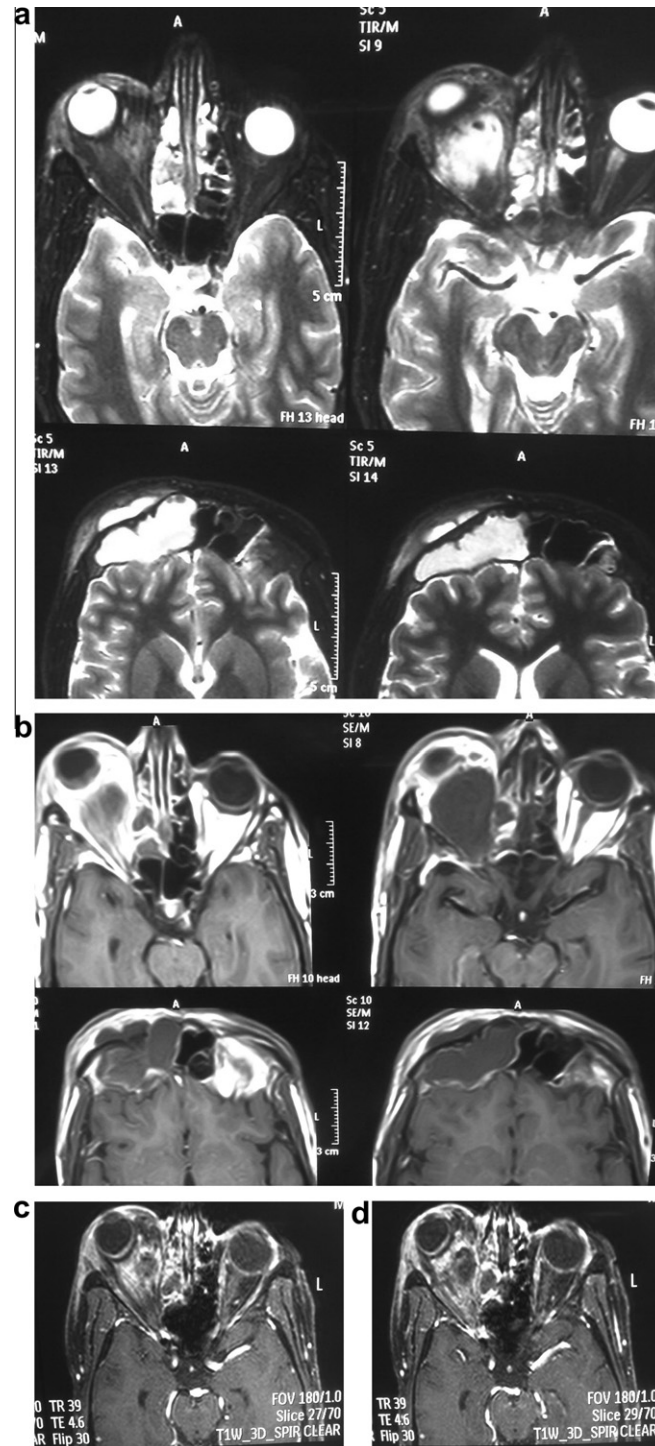
They included 6 cases (24%) with orbital lymphoma, 14 cases (56%) with non-specific orbital inflammation (NSOI) and 5 cases (20%) with orbital cellulitis.

All patients were subjected to conventional MRI with contrast and in all cases, DWI and ADC values were calculated using the MR software.

In our lymphoma patients (6 cases), 2 cases were bilateral and 4 cases were unilateral, of these 6 cases, 5 cases showed iso-intense signal at T1WI and 1 case revealed intermediate signal at T1WI, 4 cases showed high signal at T2WI and 2

cases showed intermediate signal at T2WI compared with the signal intensity of the extra-ocular muscles.

The most common pathology encountered in the present study was non-specific orbital inflammation (NSOI) in 14 cases; of these 14 cases, 10 cases revealed iso-intense signal at T1WI and 4 cases had intermediate signal at T1WI, while all 14 cases showed hyper-intense signal at T2WI. In cases of



**Fig. 3** Right orbital cellulitis with small abscess formation (a) T2 WI shows high signal intensity. (b, c and d) Heterogeneous marginal enhancement at post contrast T1 WI. (e and f) DWI and ADC show restricted diffusion within the well formed small abscess cavity. (g) ADC value of  $1.66 \times 10^{-3} \text{ mm}^2/\text{s}$ .





**Table 1** Analysis of MR findings of our cases.

	NSOI (14 cases)	Cellulitis (5 cases)	Lymphoma (6 cases)
T1	Iso-intense SI 10 cases intermediate SI 4 cases	Iso-intense SI 5 cases	Iso-intense SI 5 cases intermediate SI in 1 case
T1 + C	Mild enhancement	Mild-to-moderate enhancement	Mild heterogeneous enhancement
T2	Hyperintense SI in 14 cases	Hyperintense SI in 5 cases	High SI in 4 cases intermediate SI in 2 cases
DWI ( $b = 1000$ )	High SI in 10 cases + + low SI in 4 cases	High SI in 3 cases + low SI in 2 cases	High SI in 6 cases + + +
<i>ADC</i>			
Range ( $\text{mm}^2/\text{s}$ )	$1.1\text{--}1.3 \times 10^{-3}$	$1.5\text{--}1.7 \times 10^{-3}$	$0.6\text{--}0.9 \times 10^{-3}$
Mean ( $\text{mm}^2/\text{s}$ )	$1.2 \pm 0.1 \times 10^{-3}$	$1.6 \pm 0.1 \times 10^{-3}$	$0.75 \pm 0.15 \times 10^{-3}$

+, mildly hyper-intense.

+ +, moderately hyper-intense.

+ + +, markedly hyper-intense.

complications may be encountered in either condition. The need to rapid, accurate and also non-invasive diagnostic tools is of paramount importance (1).

Histopathology is of course very helpful. But adding complexity to the situation, obtaining orbital samples for histopathology usually requires a major surgery (orbitotomy). Another issue complicating the situation is that clinical, radiological and histopathological results are not always parallel (9,10).

DWI is a new MRI modality that can help rapid and accurate diagnosis of different orbital pathologies and proved to be highly significant in rapid diagnosis of life-threatening conditions like orbital cellulitis and nowadays it is considered a valuable modality that can eliminate the need for I.V. contrast materials that recently proved to cause nephrogenic systemic fibrosis in patients with renal failure (11).

DWI can be used confidently in diagnosing orbital abscesses even without the use of the questionable I.V. contrast materials, but when the well-formed abscess cavity that complicates orbital cellulitis is not present, the DWI can be less accurate in diagnosis because the presence of magnetic susceptibility effect that can make artifacts. So the use of ADC values can help in fast and safe discrimination of the different orbital pathologies (12).

The CT and the conventional MR sequences using T1 and T2WI images and even after contrast administration cannot clearly differentiate non-specific orbital inflammation (NSOI), orbital cellulitis and orbital lymphomas. Search for more yielding diagnostic tools is justified (1).

As regards the present study, clinical diagnosis was orbital lymphoma in 6 cases (24%) (unilateral in 4 cases and bilateral in 2 cases). The lymphoid lesions displayed high signal intensity at T2WI in 4 cases and were intermediate signals in 2 cases compared with the related extra-ocular muscles. These results were similar to Kapur et al. (1), who described the signal intensity in relation to the extra-ocular muscles instead of the retro-orbital fat at previous literatures and they found that the signal intensity ranges from iso- to hyper-intense at T2WI.

All our suspected lymphoma cases were histopathologically assessed and masses were obtained through orbitotomies. All cases proved histopathologically to be non-Hodgkin lymphomas.

Histopathology revealed a complete match between clinical and radiological diagnoses in 100% of the cases.

The most common clinical provisional diagnosis in the present study was non-specific orbital inflammation (NSOI) (14 cases representing 56%). Two cases out of 14 cases were falsely diagnosed as NSOI and proved to be cellulitis based on the clinical course and response to management.

Radiologically, the most common lesion characteristics were iso-intense signal at T1WI in 10 cases and hyper-intense signal at T2WI in 14 cases. Similar findings were evaluated by Kapur et al. (1), while the series of 74 retrospective cases analyzed by Sepahdari et al. (2) described the most common signal intensity at T2WI to be hypo-intense due to dense cellular packing and fibrosis.

In the present study, orbital cellulitis was diagnosed in 5 cases (20%). On subsequent follow-up, 1 case proved to be falsely diagnosed and proved to be NSOI also at the background of clinical course and response to treatment. The signal intensities were iso-intense signals at T1WI in all cases and high signals at T2WI in all cases.

In the present study, we analyzed the DWI and the ADC according to the free or restricted diffusion, 76% of the cases (19/25) showed hyper-intense signal at DWI  $b = 1000$ . In all 6 lymphoma patients, we noticed hyper-intense signal at DWI and the ADC value ranged from  $0.6$  to  $0.9 \times 10^{-3} \text{ mm}^2/\text{s}$ , with a mean of  $0.75 \times 10^{-3} \text{ mm}^2/\text{s}$ , these finding were similar to Sepahdari et al. (2), who concluded that the optimal threshold ADC value for differentiating benign from malignant lesion was less than  $1.0 \times 10^{-3} \text{ mm}^2/\text{s}$  and in another series of Roshdy et al. (12) the ADC values for their 2 lymphoma patients ranged from  $0.37$  to  $0.99 \times 10^{-3} \text{ mm}^2/\text{s}$ .

In our 14 cases of NSOI, 10 cases showed high signal at DWI denoting restricted diffusion; however, facilitated diffusion was seen in 4 cases, concluded that in comparison to the lymphoma patients, less restricted diffusion was noticed in NSOI. The ADC value of the NSOI patients ranged from  $1.1$  to  $1.3 \times 10^{-3} \text{ mm}^2/\text{s}$  a mean of  $1.2 \times 10^{-3} \text{ mm}^2/\text{s}$  compared with the high values of  $1.71 \times 10^{-3} \text{ mm}^2/\text{s}$  in the series of Roshdy et al. (12).

In the present study, the highest ADC values were noted in the cases of orbital cellulitis and ranged from  $1.5$  to

$1.7 \times 10^{-3} \text{ mm}^2/\text{s}$  with a mean of  $1.6 \times 10^{-3} \text{ mm}^2/\text{s}$  and the restricted diffusion was seen at the well-formed small abscess cavities in 3 cases.

The difference in diffusion restriction was explained by Kapur et al. (1), according to the difference in cellularity, necrosis and perfusion.

## 5. Conclusion

The routine conventional MRI cannot clearly differentiate the different orbital pathologies and the risk of contrast material and the biopsy, make the use of DWI and the ADC increasingly aiming at rapid, non-invasive, accurate and safe discrimination of the three overlapping orbital conditions, lymphoma, NSOI and cellulitis. Larger studies on more patients are recommended.

## References

- (1) Kapur R, Sepahdari AR, Mafee MF, et al.. MR imaging of orbital inflammatory syndrome, orbital cellulitis, and orbital lymphoid lesions: the role of diffusion weighted imaging. *AJNR Am J Neuroradiol* 2009;30(1):64–70.
- (2) Sepahdari AR, Aakalu VK, Kapur R, et al.. MRI of orbital cellulitis and orbital abscess: the role of diffusion-weighted imaging. *AJR Am J Roentgenol* 2009;193(3):W244–50.
- (3) Kato H, Kanematsu M, Tanaka O, et al.. Head and neck squamous cell carcinoma: usefulness of diffusion-weighted MR imaging in the prediction of a neoadjuvant therapeutic effect. *Eur Radiol* 2009;19(1):103–9.
- (4) Mishra AM, Gupta RK, Saksena S, et al.. Biological correlates of diffusivity in brain abscess. *Magn Reson Med* 2005;54:878–85.
- (5) Garcia-Perez AI, Lopez-Beltran EA, Kluner P, Luque J, Ballesteros P, Cerdan S. Molecular crowding and viscosity as determinants of translational diffusion of metabolites in subcellular organelles. *Arch Biochem Biophys* 1999;362:329–38.
- (6) Koç O, Paksoy Y, Erayman I, Kivrak AS, Arbag H. Role of diffusion weighted MR in the discrimination diagnosis of the cystic and/or necrotic head and neck lesions. *Eur J Radiol* 2007;62:205–13.
- (7) Lee AG, Brazis PW, Garrity JA, White M. Imaging for neuro-ophthalmic and orbital disease. *Am J Ophthalmol* 2004;138:852–62.
- (8) Hakyemez B, Ergin N, Uysal S, Isik I, Kilic E. Diffusion-weighted MRI in the differentiation of brain abscesses and necrotic tumors. *Tani Girisim Radyol* 2004;10:110–8.
- (9) Romano A, Bozzao A, Bonamini M, Fasoli F, Ferrante M, Floris R, et al.. Diffusion-weighted MR imaging: clinical applications in neuroradiology. *Radiol Med* 2003;106:521–48.
- (10) Chandler JR, Langenbrunner DJ, Stenvens ER. The pathogenesis of orbital complication in acute sinusitis. *Laryngoscope* 1970;80:1414–28.
- (11) Kuo PH E, Abu Alfa AK, Cower SE. Gadolinium-based MR contrast agent and nephrogenic systemic fibrosis. *Radiology* 2007;242:647–9.
- (12) Roshdy N, Shahin M, Kishk H, et al.. New imaging modalities in diagnosis of orbital masses: a clinico-pathologic correlation middle east. *J Ophthalmol* 2010;17:175–9.